

WE CLAIM:

1. An axially extending rechargeable electrochemical cell comprising:
- (a) an outer can defining an internal cavity with an open end, a positive and negative electrode disposed in the internal cavity, and a terminal end cap enclosing the open end; and
- 5 (b) an end cap assembly including:
- i. a grommet extending radially inwardly from the can, wherein the grommet flexes from a first position towards a second position in response to internal cell pressure;
- 10 ii. a first conductive element in electrical communication with the terminal end cap;
- iii. a second conductive element in electrical communication with the positive electrode, and in removable electrical communication with the first conductive element, wherein the second conductive element is in mechanical communication with the grommet; and
- 15 wherein the first and second conductive elements are removed from electrical communication when the grommet flexes towards the second position in response to an internal pressure exceeding a predetermined threshold during charging.
2. The electrochemical cell as recited in claim 1, wherein the grommet returns to the first position from the second position when the internal pressure drops below the predetermined threshold.
3. The electrochemical cell as recited in claim 1, wherein the second conductive element is connected to the grommet and at least partially axially aligned with the first conductive element, and wherein the second conductive element is displaced axially outwardly when the grommet is in the second position.
4. The electrochemical cell as recited in claim 1, further comprising a nonconductive spring member disposed between the terminal cap and the grommet to limit the amount of grommet displacement and to impose a pre-disposed spring force for maintaining contact between the first and second conductive elements.

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5. The cell as recited in claim 1, wherein the grommet defines a radially inwardly extending cavity at its periphery, the cavity including distal ends of the end cap and first conductive element.

6. The cell as recited in claim 5, wherein the can is crimped over the grommet to seal the open end of the cell.

7. The cell as recited in claim 1, wherein the terminal end cap is a positive terminal end cap.

8. The cell as recited in claim 1, further comprising a stop washer disposed axially downstream of the first conductive element for limiting axial movement of the first conductive element when the grommet is in the second position.

9. The electrochemical cell as recited in claim 1, further comprising an aperture extending through the terminal end cap configured to permit gasses to escape from the cell when the internal pressure exceeds the predetermined threshold.

10. The electrochemical cell as recited in claim 1, wherein the grommet separates the internal cavity of the can from a second internal cavity disposed within the end cap, the cell further comprising an opening extending through the grommet to provide a conduit between the internal cavity of the can and the second internal cavity;

11. The electrochemical cell as recited in claim 10, further comprising a plug disposed within the opening that is displaceable when the internal pressure reaches a second predetermined threshold.

12. The electrochemical cell as recited in claim 11, wherein the plug is elastically deformable.

13. The electrochemical cell as recited in claim 10, further comprising a spring member disposed within the opening operable to prevent fluid from flowing

from the internal cavity of the can from the second internal cavity, wherein the spring member is displaceable when the internal pressure reaches a second
5 predetermined threshold.

14. The electrochemical cell as recited in claim 10, wherein the cell is chargeable under a constant current charge.

15. The electrochemical cell as recited in claim 1, wherein the cell is chargeable at rate faster than one hour.

16. The electrochemical cell as recited in claim 1, wherein the cell is chargeable under a constant voltage charge.

17. The electrochemical cell as recited in claim 1, wherein the cell is chargeable under a varying current charge.

18. The electrochemical cell as recited in claim 17, wherein the varying current charge is a half-wave rectified alternating current charge

19. The electrochemical cell as recited in claim 17, wherein the varying current charge is a full-wave rectified alternating current charge.

20. The electrochemical cell as recited in claim 17, wherein the varying current charge is an alternating current offset by a direct current.

21. The electrochemical cell as recited in claim 1, wherein the cell is chargeable with a voltage that varies between a minimum threshold and a maximum threshold.

22. The electrochemical cell as recited in claim 1, further comprising a separator disposed between the positive and negative electrodes, wherein the separator is gas impermeable.

23. The electrochemical cell as recited in claim 1, wherein the second conductive element further comprises:

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a first contact having one end extending from the positive electrode, and a second end opposite the first end;

a second contact extending through the grommet having a first end in contact with the second end of the first contact, and a second end opposite the first end; and

10 a third contact having a first end in contact with the second end of the second contact, and a second end opposite the first end and in removable contact with the first conductive element.

24. A rechargeable electrochemical cell charging system comprising:

(a) an electrochemical cell including:

5 i. an outer can defining an internal cavity with an open end, an anode and cathode disposed in the internal cavity, and a terminal end cap enclosing the open end;

ii. a linkage that establishes an electrical connection between the terminal end cap and first electrode; and

10 iii. a switch responsive to high internal pressure to break the linkage; and

(b) a cell charger that receives the electrochemical cell therein and is configured to supply a constant voltage charge thereto, wherein internal pressure is generated during charging that activates the switch to terminate the charge when the internal pressure exceeds a predetermined threshold.

25. The charging system as recited in claim 24, wherein the cell further comprises a gas impermeable separator disposed between the anode and cathode.

26. The charging system as recited in claim 24, wherein the cell further comprises a ratio of anode capacity in ampere-hour to cathode capacity in ampere-hour within the range of .9:1 to 1.5:1 by weight.

27. The charging system as recited in claim 24, wherein the charger is further configured to supply a charge having a varying current to the cell.

28. The charging system as recited in claim 24, wherein the charger supplies a current to the cell that decreases as voltage within the cell increases during charging.

29. The charging system as recited in claim 24, wherein the electrical connection further comprises a first contact in electrical communication with the terminal end cap, and a second contact in electrical communication with the cathode and in removable electrical communication with the first contact, and wherein the switch interrupts the electrical communication between the first and second contacts when the internal pressure exceeds a predetermined threshold.

30. The charging system as recited in claim 29, wherein the switch further comprises a grommet connected to the first contact and configured to bias the first contact away from the second contact.

31. The charging system as recited in claim 24, wherein the switch is reversible.

32. A rechargeable electrochemical cell charging system comprising:

(a) an electrochemical cell including:

i. an outer can defining an internal cavity with an open end, an anode and cathode disposed in the internal cavity, and a terminal end cap enclosing the open end;

ii. a linkage that establishes an electrical connection between the terminal end cap and first electrode; and

iii. a switch responsive to high internal pressure to break the linkage; and

(b) a cell charger that receives the electrochemical cell therein and is configured to supply a varying current charge thereto, wherein internal pressure is generated during charging that activates the switch to terminate the charge when the internal pressure exceeds a predetermined threshold.

33. A rechargeable electrochemical cell charging system comprising:

(a) an electrochemical cell including:

i. an outer can defining an internal cavity with an open end, an anode and cathode disposed in the internal cavity, and a terminal end cap enclosing

5 the open end;

ii. a linkage that establishes an electrical connection between the terminal end cap and first electrode; and

iii. a switch that activates in response to high internal pressure to break the linkage; and

10 (b) a cell charger that receives the electrochemical cell therein and is configured to supply a voltage charge thereto, wherein the voltage alternates between a maximum threshold and a minimum threshold, wherein internal pressure is generated during charging that activates the switch to terminate the charge when the internal pressure exceeds a predetermined pressure threshold.

34. A method for charging a rechargeable cell of the type having an outer can defining an internal cavity having an open end, an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end, an electrical linkage that removably connects the end cap with the cathode, and a switch
5 controlling the linkage, the method comprising;

(a) supplying a constant voltage charge to the cell, wherein internal pressure accumulates within the internal cavity in response to the constant voltage charge; and

10 (b) activating the switch to terminate the linkage when the internal pressure exceeds a predetermined threshold.

35. The method as recited in claim 34, further comprising:

(c) activating the switch to reinstate the linkage once the internal pressure falls below the predetermined threshold; and

(d) measuring the open current voltage of the cell; and

5 (e) repeating steps (b) and (c) until the cell has an open circuit voltage of approximately 1.42 volts.

36. The method as recited in claim 34, further comprising connecting a plurality of additional rechargeable cells in series with the rechargeable cell during charging.

37. The method as recited in claim 34, further comprising connecting a plurality of additional rechargeable cells in parallel with the rechargeable cell during charging.

38. The method as recited in claim 34, wherein the an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end in removable electrical communication with the cathode, and a switch controlling the electrical communication between the terminal end cap and the cathode,

39. The method as recited in claim 34, further comprising supplying a decreasing current to the cell as internal cell voltage accumulates.

40. The method as recited in claim 34, further comprising reversing the switch to re-establish the linkage when the internal pressure falls below the predetermined threshold.

41. A method for charging a rechargeable cell of the type having an outer can defining an internal cavity having an open end, an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end, an electrical linkage establishing a removable electrical connection between the end cap and cathode, and a switch controlling the linkage, the method comprising;

(a) supplying a varying current charge to the cell, wherein internal pressure accumulates within the internal cavity in response to the charge; and

(b) activating the switch to terminate the linkage when the internal pressure exceeds a predetermined threshold.

42. The method as recited in claim 41, further comprising connecting a plurality of additional rechargeable cells in series with the rechargeable cell during charging.

43. The method as recited in claim 41, further comprising connecting a plurality of additional rechargeable cells in parallel with the rechargeable cell during charging.

44. The method as recited in claim 41, wherein the an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end in removable electrical communication with the cathode, and a switch controlling the electrical communication between the terminal end cap and the cathode.

45. The method as recited in claim 41, further comprising reversing the switch to re-establish the linkage when the internal pressure falls below the predetermined threshold.

46. A method for charging a rechargeable cell of the type having an outer can defining an internal cavity having an open end, an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end, an electrical linkage that removably connects the end cap with the cathode, and a switch
5 controlling the linkage, the method comprising:

(a) supplying an voltage charge to the cell that varies between a predetermined minimum and a predetermined maximum, wherein internal pressure accumulates within the internal cavity in response to the charge; and

(b) activating the switch to terminate the linkage when the internal pressure
10 exceeds a predetermined threshold, wherein the linkage is re-established when the internal pressure falls below the predetermined threshold.

47. A rechargeable electrochemical cell charging system comprising:
a rechargeable cell having a gauge on its outer surface operable to send a signal indicating that the outer surface is expanded at a rate that is beyond a predetermined threshold; and

5 a battery charger configured to (1) supply a charge to the rechargeable cell, wherein the outer surface of the battery expands as the charge is supplied, (2) receive the signal from the gauge, and (3) terminate the charge based on a predetermined rate of change of outer surface expansion.

48. The assembly as recited in claim 47, wherein the gauge is a strain gauge having two distal ends connected to two respective conductive contact bands, and wherein the charger further comprises conductive leads connected to the contact bands to measure electrical resistance thereacross.

49. The assembly as recited in claim 48, wherein the signal from the gauge is a resistance that varies in a predictable manner relative to the outer surface expansion, and wherein the charger further includes a processor operable to measure the resistance across the strain gauge.

50. The assembly as recited in claim 47, wherein the charge is a constant voltage charge.

51. The assembly as recited in claim 47, wherein the cell further includes a temperature sensor for sensing the internal temperature of the cell, wherein the battery charger further terminates the charge based on a predetermined condition of temperature and change of outer surface expansion.

52. The assembly as recited in claim 47, wherein the strain gauge is embedded in a laminate configured to be wrapped around the cell, the laminate including: an adhesive, an insulator, the strain gauge, and a pair of contact pads disposed adjacent and in electrical communication with the strain gauge.

53. A method for determining a charge termination point of a rechargeable electrochemical cell of the type having an outer can defining an internal cavity having an open end, an anode and cathode disposed in the internal cavity, a terminal end cap enclosing the open end, and a strain gauge disposed on an outer surface of the cell whose resistance changes in response to expansion of the cell, the method comprising:

supplying a charge to the cell;

measuring the resistance of the strain gauge; and

determining the charge termination point based on the resistance changes of the strain gauge during charging.

54. The method as recited in claim 53, wherein the charge is a constant voltage charge.

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